Differential Locking System

This invention relates to a differential locking device for use with vehicles and to a method of installing a differential locking device onto a range of vehicle axles.

The differential locking assembly is an already well known and reliable component, particularly in the field of off road and agricultural vehicles. Many vehicles though, that are used for this type of work do not have them fitted and would greatly benefit by having them.

The after market differential locking systems presently available tend to be complicated and/or costly to produce and fit, particularly in the case of pneumatic, vacuum or cable systems. Also, the proposed system is not intrusive to the axle tubing itself, and therefore does not interfere with structural integrity of the axle assembly.

It is a feature of the present invention that it can provide a simple, cheap to produce device and system which is easy to install and, once fitted, is easy to inspect and adjust. The positioning of the locking assembly also has the advantage of not fouling any exhaust, brake line or suspension components etc. The system may also apply to a range of vehicles, be it new vehicles or retro fitting onto existing older vehicles.

The invention provides a differential pan removably attachable to a vehicle to cover the differential unit of the vehicle and a locking device able to be fitted to the differential unit of the vehicle in which, when the differential pan is attached to the vehicle, the locking device can be attached to the vehicle differential unit inside the differential pan.

Mounting a locking assembly under a removable differential cover creates an environment within the differential housing assembly, which has previously not been

available, namely an area suitable to fit a differential locking device.

In a preferred method of installing the device of the invention to a vehicle a shaped mounting ring is fixed (preferably welded) onto the rear of the axle assembly of the vehicle, in place of the conventional differential pan. A removable differential cover, which is also sufficiently large enough to accept the complete locking assembly and actuator, is fitted to the mounting ring, encasing the entire assembly. A solenoid (or other mechanical actuator device) is mounted inside the shaped ring, parallel to the half shaft of the vehicle to operate the locking device. The solenoid is connected to a fork, which in turn communicates reciprocal movement which engages/disengages a sliding dog gear (splined to the half shaft) into a splined bearing journal located in the differential carrier. This action causes the opposing half shafts to be locked together or independent as desired.

A switching device such as a microswitch, can easily be fitted inside the diff casing and can be used warn the vehicles driver of the operational status of the differential locker, for example: a lamp may be illuminated or a warning alarm may sound when the locker is engaged. The switch may be operated by the reciprocal movement of the solenoid or actuator. The mounting for the switch may be incorporated into the differential carrier's bearing adjuster locking tab fixing point, by means of combining the switch mounting plate with the locking tab. It may also be fitted in any other position suitable for the available space constraints. Another method for operating the warning device could employ a current sensor on the solenoid wiring.

It is a feature of the present invention that it is cheap to produce with very few components; it is versatile and can be fitted to the majority of different vehicles; can be installed on new vehicles or retrofitted. It is easy to install and easy to inspect and adjust after assembly. Safety features which can be included are that, when the power is off, the device is unlocked and there can be an optional manual override.

A specific embodiment of the system will now be described by way of an example, with reference to the accompanying drawings. A retrofit example will be described herein, but the same basic procedures and functions would also apply to production line new vehicles.

In the drawings

Fig. 1 is a plan view of the device looking from the rear of the axle, with cover removed.

Fig. 2 is a view of the splines and locking components

Fig. 3 is a view of the actuator fork assembly

Fig. 4 is a view of an alternative mounting position for the actuator; i.e. on the differential carrier bearing.

Fig. 5 shows material removed from the axle casing

Fig. 6 is a view of a manual override and

Figs. 7 and 8 shows a shaped differential pan.

Referring to figs. 1 to 4 the differential carrier core assembly (2) is fitted with a splined bearing journal (1) at one end. This journal will perform for both the diff carrier core and associated sun gear. This can be achieved by machining off the original bearing journal at (3), internally splining the remaining casting (2) at position (9) and press fitting (interference fit) an externally splined bearing journal (1). A special half shaft is fitted with a lengthened spline shaft at the differential end. A sliding dog gear (5) with internal splines to match the half shaft is fitted onto the half shaft upon assembly. It also has external splines to match the differential carrier splines, (although in some cases it is also preferable to have external splines on the differential carrier on an extended journal, and matching internal splines on the sliding dog.) The purpose of this sliding dog gear is to allow the half shaft to be connected to the differential carrier. The splines on the bearing journal and sliding dog are designed to easily mate.

To engage the differential lock, the sliding dog is forced inwards along the half shaft spline and locks into the spline previously mentioned in the differential carrier. This causes the two half shafts to be locked together, to create an even amount of drive to both connected half shafts, and thus turn the vehicle wheels evenly. The sliding dog's movement in the example is caused by an electric solenoid (4), (Figure 3) (but any conventional assembly will also work), positioned parallel to the half shaft, mounted either above the differential carrier bearing (4) (Figure 4), or (as in this example) onto axle casing, opposed to the differential carrier (Figure 1A). Movement to the dog is communicated via a fork (6) connected to the solenoid.

The solenoid preloads a spring mounted in front of the fork (6) which in turn, transfers its energy to engage the dog gear into the differential carrier spline. A return spring is also installed to aid disengagement, in this example at (7).

To allow the above to be fitted into a conventional banjo type axle assembly, the old differential pan must firstly be removed (or not fitted in the case of a new vehicle). A special differential pan mounting ring (8), which is shaped to allow the fitment of the solenoid or actuator, is then fitted to the axle casing (10), in place of the old differential pan. This can have either threaded holes, studs or similar mountings attached and must be substantial enough to reinforce the axle casing. If the ring is to be welded to the axle, mounting studs for the differential pan can be used to lift the ring away from the axle to create a space suitable for a welding bead, by protruding through the bottom of the ring. The axle assembly can then be reinstalled with differential and locking assembly.

Referring to fig. 5 in some cases there is not enough clearance between the axle housing and the differential bearing cap (1) to allow the fork to move fully. In these cases material can safely be removed from the axle casing (2), as the new differential pan mounting ring also acts as a reinforcing plate. The solenoid may also be mounted on the ring at (3).

In the case of axles that already have removable differential pans, an adaptor plate may be fitted, utilising the existing holes in the axle case, to allow the new type of differential cover to be fitted, thus giving the space and environment needed to install the system as described.

Referring to figures 7 and 8 a new shaped differential pan can then fitted, (1) along with a suitable gasket material, which allows the locking assembly to fit and operate. A simple electronic switch can be used to operate the system, via a warning lamp and relay. The wiring must also be water resistant and located in such a position to not let water into differential case or let oil out. An oil level plug to allow for new level of oil should also be added (2).

Referring to figure 6 a manual override can also be added to the unit. An example of this is to add a protruding rod (1) through the differential cover (2) & seal (3), which would communicate linear movement to the solenoid or actuator (4), which in turn would manually engage or disengage the locking dog, by locking lever (1) (through bush (7) in place by use of locking pin (5), into slots (6). This may be desirable in the case of an electrical failure within the vehicle.

It is proposed that ABS plastic would be a suitable material for the new differential pan, but steel or another material (such as Aluminium or Polycarbonate) may also be practicable. If ABS is used, a steel guard may be desired. This could be fitted to the differential pan mounting ring giving additional strength to the differential pan. Reinforcing webs would also be a desired feature, adding strength to the pan. The pan should also be made such that is can be used to cover the solenoid (or actuator) when it is fitted to either above the bearing caps or onto the axle casing.

Referring to figure 8 a magnetic sump plug (5) may also be added to ensure metallic particles do not foul in the solenoid and/or locking mechanism.